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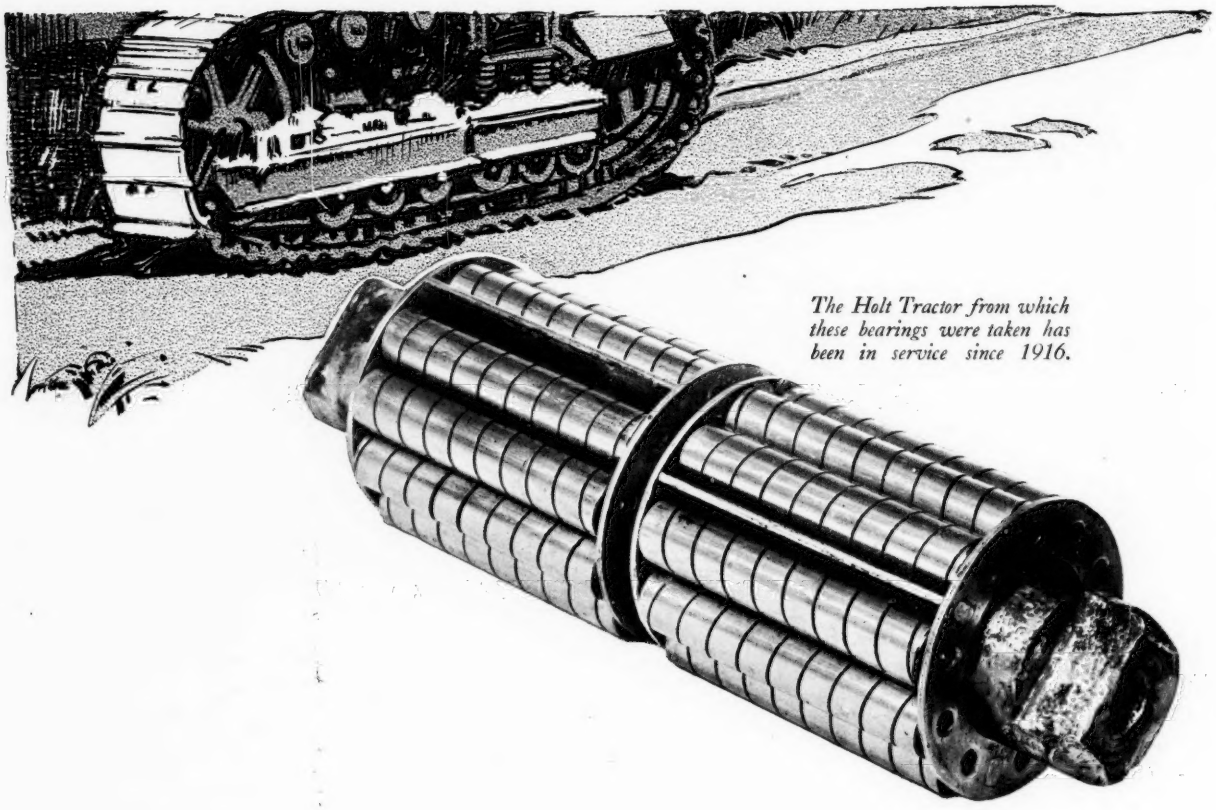

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Volume 3 MAY, 1922 Number 5

Relation of Lug Equipment to Traction*

By R. U. Blasingame
Mem. A. S. A. E. Professor of Agricultural Engineering,
Pennsylvania State College

THE relation of lug equipment to traction is one of the most important factors in the tractor problem today. There is a lack of basic information relating to this important factor. This statement is borne out by the opinions expressed by both manufacturers of wheel tractors and agricultural engineers. Obviously, agricultural engineering departments of state agricultural colleges contemplating a program of tractor research should include this feature of the subject as one of prime importance.

As exceptions to the above, two striking pieces of work on the subject should be mentioned which have so far yielded the most of the data which is available.

In his report on "The Principles of the Wheeled Farm Tractor," E. R. Hewett found in a series of laboratory tests on full sized wheels that:

1. The maximum drawbar pull is a definite function of the weight per inch of width. Weights used varied from 10 to 200 pounds per inch; the ratio of maximum possible drawbar pull to total weight on the wheel was constant for that range. This was found to be true whether the ground was wet or dry.

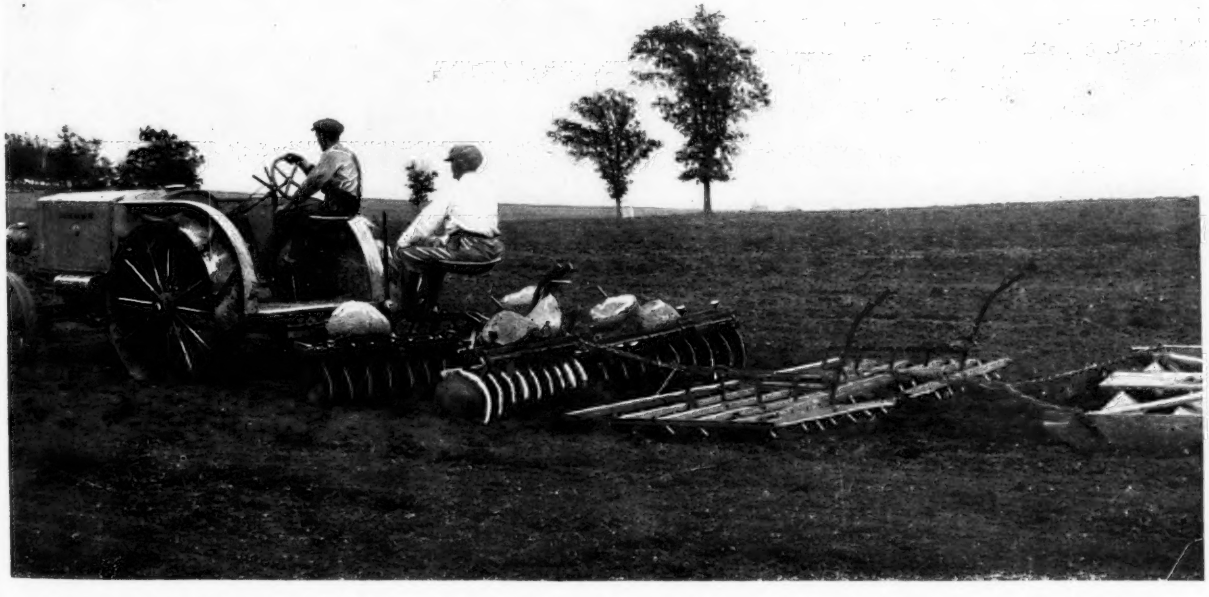
2. On sandy ground the drawbar pull available with a smooth metal wheel is about 30 per cent of the weight on the wheel.

3. On damp, sandy ground, the maximum drawbar pull is greater, being about 43 per cent of the weight, and under some conditions even slightly higher.

4. Cleats increase the maximum drawbar pull only insofar as the soil resists shearing; that is, the cleat carries a section of the top soil and slides it against the soil below the edge of the cleat. Experiments indicated that this was practically independent of the depth of the cleat, depending solely on the shearing strength of the soil at the depth of the cleat edge. In some cases the shallower cleat pulled more than the deeper cleat because the roots in the sod were not cut off and advantage was taken of their shearing strength.

It was found that a cleat inclined forward at an angle would improve this condition somewhat. In going uphill the cleat enters the soil almost horizontally, acting like a step and tending to lift the weight off the wheel. On leaving, the cleat stands almost vertical and causes less friction and loss of power. An inclination of about 30 degrees was found to be the most satisfactory on a 6-foot wheel. This arrangement tends to self-cleaning to a certain extent. Setting the cleats at an angle of 30 degrees to the axis of the wheel also helps this cleaning effect by a slipping action.

*Paper presented at the fifteenth annual meeting of the American Society of Agricultural Engineers, Chicago, December 27, 28, and 29, 1921.



The fundamental part of tractor use, gearing the traction member to the ground, is the one least understood

The shearing strength of the soils tested appeared to vary from 5 pounds per inch of width in dry molding sand to 75 pounds in loam or sod. No doubt tough sod or gumbo may prove even stronger than this.

From these facts it becomes evident that weight is the only means of obtaining a tractive effort of 40 per cent of the weight of the machine under bad conditions in dry ground or sand, as cleats will be of little use. Wheels 72 inches wide would give an added pull due to the use of cleats of only 360 pounds for loose ground. Weight is therefore practically the sole reliance for traction in sand or very dry loose ground. In sod or damp ground 72-inch wheels would ordinarily give 4000 to 5000 pounds pull from the cleats alone, and the light machine with only sufficient weight to hold the cleats down would show good results.

In a series of tests at Purdue agricultural experiment station the percentage of slippage of tractor wheels with different lug equipment was determined on a sandy loam soil which dries out hard but disintegrates under the tractor wheel and provides the poorest sort of footing.

As the tests progressed, it became evident that the manner in which the ground was cut by the wheel equipment and the spacing of the cuts markedly influenced the amount of slippage with projecting angle-iron cleats; the slippage amounted to 40 per cent under an average two-plow load, resulting in the conclusion that the extension angle is not the cleat for bare, dry soil of sandy texture. There was a decrease of 20 per cent in the slippage when extension rims were bolted inside the projecting angles, giving a 17-inch wheel face. This increased resistance to the backward push of the cleat was due to the firming effect of the rim on the soil.

When using narrow rims with lugs there was 16⅔ per cent slippage between no load and the average load. The slippage was 6.8 per cent when extension rims with lugs were used.

SPECIAL LUGS AND TREADS IMPROVE TRACTION

Fine results were obtained on wet ground in the spring. The "P-T" wheel equipped tractor pulled its plow up a seepy, clay hillside where the other wheel tractors would bog. The lip clear across the face of the pad gave a good holding power when pressed into the ground by the weight of the tractor, but in dry ground this same lip was a detriment as the cuts made a series of blocks which slipped back as the thrust came against the horns of the pads. The slippage on the dry, sandy ground was rather high amounting to 10 per cent. Since there is no direct disturbance of the ground by the rims of the wheel the pads afford a good opportunity to study the resistance of the soil as the tractor is forced ahead.

The tractor running all four wheels on the land was found to be at a disadvantage when pulling a two-bottom plow on bare, sandy, dry soil, as the constant crushing in of the furrow wall and the offset hitch made the tractor run on the skew and out of level. The thin spades entered and left the soil with but little disturbance, and when the plow was let down to give a stalling load, the motor stopped before the wheels would spin. This was the only case where the holding power of the wheels exceeded the motor power. To push in and withdraw the spades took power as was indicated by a slight increase in fuel consumption, but satisfaction from an owner's standpoint would come from its ability to go ahead taking the ground as it came.

The final wheel equipment tested on the in-furrow were the "Grid-Iron-Grips" attachment. These are designed for plain wheel rims, and have the same end in view as the "P-T" wheel, but accomplish the end in a somewhat different way. In effect, gear teeth about four inches narrower than the width of the rim are bolted to the rim. These force the tractor ahead by meshing in the backs of the shoes as they are laid on the ground. The tractor rolls on the part of the rim outside of the teeth, so the backs of the shoes furnish the grip for the teeth, and the track on which the wheels roll. The shoes are loosely attached so they remain flat on the ground until the wheel passes over. The "Grips" gave very good results, showing less than six per cent slippage. The slippage would have been still less if there had been fewer prongs on the shoes.

The "Miller Tractred," which has been designed as an attachment for the Fordson tractor, was tried under a variety of soil conditions during the last week of October, 1920.

The following results were obtained from the tests performed:

	Miller Tractreds	Round Wheel
On hard road, weighted sled as load		
Average drawbar pull in pounds	1800	1400
Oliver No. 7 plow in loam soil		
Average drawbar pull in pounds	1800	1400
Maximum drawbar pull in pounds	2300	1800
Oliver No. 7 plow in gravelly slope, approximately 12% grade		
Average drawbar pull in pounds	1800	1400
Maximum drawbar pull in pounds	2200	1800
Plowing speed with two 14-inch bottom plows, plowing approximately 8 inches deep. Tractor running in second speed		
Speed in miles per hour	2.09	2.70
Slippage in per cent at above speed	.05	15.9

Miller Tractreds increased the traction about 22 per cent over what was obtained from the round wheel.

Tests with the "Bentz" tractor lug were started at Pennsylvania State College with the idea of determining its efficiency as compared with various other lugs commonly furnished to the Pennsylvania farmer. The "Bentz" lug has a "quick detachable" feature which would be a distinct advantage in the state if the lug could be built cheaply enough and still have all the qualities of a good lug. Pennsylvania has a great mileage of improved state highways on which farm tractors often must travel in passing from one field to the other. In such a case the farmer must either remove his lugs or buy a license. This condition has caused a great deal of dissatisfaction among the farmers and much discussion in the legislature.

While the tests thus far conducted have indicated in most cases that the Bentz lug is somewhat superior to the angle iron, yet they have not been compared with the various other types of lugs which can be secured.

The tests were all run with the I.H.C. 8-16 tractor in competition with the regular extension angle iron cleat on the clay loam and sandy loam. The tests in sandy soil which were conducted in New Jersey with the Bentz lug were in competition with the California angle-iron cleat.

While the protection of the improved road from the effects of tractor lugs is important, there are such widely differing soil types and conditions brought about by diversified cropping systems in Pennsylvania that it is believed there is a distinct need for different types of lug equipment on individual farms if the best results are to be obtained.

The Bentz tractor lug system is so arranged that they can be attached or detached from the tractor wheel in a comparatively short time. In fact, the time required for putting the lugs on both wheels of an I.H.C. 8-16 tractor was fourteen minutes, and five minutes to remove them. This did not include the time required to jack up the tractor as this would vary with the kind of hoisting apparatus used. It should be said, however, that the man doing the work was Mr. Bentz himself who, of course, was familiar with the lug equipment and could distinguish the right and left lugs at a glance.

When the lugs have been applied to the wheel, they are

held on by one bolt. These lugs hook over the edge of the wheel and each lug hooks over the one next to it. Friction between the wheel and the lugs is depended upon to resist the thrust of the wheel in moving forward.

The lugs which were used in the test were made of cast steel. Very little wear took place and no breakage. While cast steel is more expensive than malleable iron, yet there are places where steel might be preferable.

The bar lugs to lock with each other must be placed at alternate angles with the axis. One set of bar lugs was 3 inches high and the other set 4 inches. The base of the lugs next to the wheel is 2½ inches. To reduce the weight they were cast hollow, having a wall thickness of about ⅜ inch.

The tri-spade lugs were cast with three spades on each casting. These spades were 3 inches high, 2½ inches wide, and were staggered on the wheel when in place similar to the bolt on spade lugs.

An Italian spring dynamometer was used, the spring being calibrated in a testing machine in the engineering laboratory before the tests were run.

The time was taken with a stop watch in traveling 50 feet when the dynamometer tests were made. Two dynamometer cards were taken in both directions in each test on level and rolling ground and the pounds pull averaged. Also the travel in feet per minute for the two tests was averaged. On the grades the dynamometer was used only on the upgrade.

The slippage was determined by allowing the tractor to travel over a measured distance of 500 feet without load and the revolutions of both drivewheels noted. The count was taken in both directions in each test, and averaged, on rolling and level ground. On grades the drivewheel observations were made only on upgrade. Then the tractor pulled the plow or disk over the same distance and the revolutions on the drivewheels noted.

The drawbar horsepower of the tractor was calculated by multiplying the average pounds pull by the travel in feet per minute, and dividing by 33,000. The per cent slippage was determined by subtracting the slippage without load from the slippage with load, and dividing by the slippage without load.

The tests were conducted on three soil types: Clay loam, sandy loam, and sandy soil. The first two soils were located near Lebanon, Pennsylvania, while the other was located near Mt. Holley, New Jersey.

The accompanying tables give the results of the tests with Bentz lugs.

TABLE 1. PLOWING ON 4 PER CENT GRADE
CLAY LOAM SOD

Type Tractor	Type Lugs	Operation	Grade	Per cent Slip	Average lbs. Pull	Speed in Ft. Per Minute	Drawbar H.P.
I. H. C.	Angle iron	Plowing	4%	17.4	1627	189.6	9.3
I. H. C.	Tri-spade	Plowing	4%	9.4	1537.3	210	9.8
I. H. C.	3″ Bar lug	Plowing	4%	8.6	1478.2	213	9.5

TABLE 2. PLOWING LEVEL GROUND
CLAY LOAM SOD

Type Tractor	Type Lugs	Operation	Grade	Per cent Slip	Average lbs. Pull	Speed in Ft. Per Minute	Drawbar H.P.
I. H. C.	Angle Iron	Plowing	Level	17.3	1819.1	158.7	8.7
I. H. C.	Tri-spade	Plowing	Level	7.8	1734.9	174	9.2
I. H. C.	3″ Bar lug	Plowing	Level	10.1	1716.4	170.1	8.9
I. H. C.	4″ Bar lug	Plowing	Level	7.4	1833.1	159	8.8

TABLE 3. DISKING ROLLING GROUND
CLAY LOAM PLOWED

Type Tractor	Type Lugs	Operation	Grade	Per cent Slip	Average lbs. Pull	Speed in Ft. Per Minute	Drawbar H.P.
I. H. C.	Angle iron	Disking	Roll	20.3	11.58	174	6.1
I. H. C.	Tri-spade	Disking	Roll	16.7	1202.9	184.5	6.7
I. H. C.	3″ Bar lug	Disking	Roll	15.2	1179.2	186	6.6
I. H. C.	4″ Bar lug	Disking	Roll	13.8	1123.2	206.1	7.01

TABLE 4. DISKING ON 8.2 PER CENT GRADE
SANDY LOAM PLOWED

Type Tractor	Type Lugs	Operation	Grade	Per cent Slip	Average lbs. Pull	Speed in Ft. Per Minute	Drawbar H.P.
I. H. C.	Angle iron	Disking	8.2%	23.1	942.6	115.2	3.3
I. H. C.	Tri-spade	Disking	8.2%	13.2	821.4	181.8	4.5
I. H. C.	3″ bar lug	Disking	8.2%	20	795.3	187.2	4.5
I. H. C.	Tri-spade & extension rims	Disking	8.2%	10.4	823.9	181.8	4.5

TABLE 5. DISKING ON ROLLING GROUND
CLAY LOAM PLOWED

Type Tractor	Type Lugs	Operation	Grade	Per cent Slip	Average lbs. Pull	Speed in Ft. Per Minute	Drawbar H.P.
I. H. C.	Angle iron	Disking	Roll	26.8	1094.1	154.9	5.09
I. H. C.	Tri-spade & extension rims	Disking	Roll	16.4	1497.3	188.2	6.2

The following shows the comparison of fuel consumption and time required in disking with angle-iron cleats and Bentz tri-spade lugs with extension rims. This run was made the same day and in the same field in which test No. 3 was conducted.

Angle Iron		Bentz tri-spade and extension rims	
Fuel-gallons	Time-hours	Fuel-gallons	Time-hours
20.5	10	16.5	7.2

TABLE 6. DISKING ON SANDY SOIL ON ROLLING GROUND
ORCHARD

Type Tractor	Type Lugs	Operation	Grade	Per cent Slip	Average lbs. Pull	Speed in Ft. Per Minute	Drawbar H.P.
I. H. C.	Angle Cal. lugs	Disking	Roll	12.0	903.4	183.1	4.98
I. H. C.	Bentz tri-spade with extension rims	Disking	Roll	11.0	896	190.5	5.11
I. H. C.	Bentz 4″ bar lug	Disking	Roll	11.0	1005.9	175.4	5.3

TABLE 7. DISKING ON ROLLING LAND
SANDY LOAM PLOWED

Type Tractor	Type Lugs	Operation	Grade	Per cent Slip	Average lbs. Pull	Speed in Ft. Per Minute	Drawbar H.P.
I. H. C.	Angle iron	Disking	Roll	6.	679.3	200	4.11
I. H. C.	Bentz tri-spade	Disking	Roll	9.	650.9	214.2	4.2
I. H. C.	Bentz tri-spade with extension rims	Disking	Roll	4.2	665.2	214.2	4.3
I. H. C.	Bentz 3″ bar lug	Disking	Roll	6.8	694.4	200	4.2

In the light of the limited data which is available on this subject, it is impossible to draw any definite conclusions or set down any definite recommendations as to the best lug for any particular condition. Therefore, I wish to suggest: First, that the Standards Committee of the American Society of Agricultural Engineers standardize traction devices, and, second, that the Research Committee outline some definite plan or method for conducting tests with various traction devices.

Standard Code for Testing Tractors*

THE object of this report is to recommend a standard method or code for rating tractors, by which either new or old models may be accurately rated. The rating is to consist of

(a) Brake horsepower rating as delivered to the pulley on the machine driven

(b) Drawbar rating as delivered to the drawbar at plowing speeds

BRAKE HORSEPOWER RATING

The following tests shall be conducted on each tractor selected by the board of engineers in charge of the tests:

A. "Limbering-up" run

The object of this run is to take out the stiffness likely to be found in a new machine. Tractors in this run will be used to pull harrows, packers, or anything that will furnish a suitable drawbar load.

The loads to be pulled will be (1) approximately one-third load for four hours, (2) approximately two-thirds load for four hours, and (3) approximately full load for four hours.

If the tractor manufacturer believes that twelve hours is not sufficient length of run to get the tractor limbered up, reasonable additional time will be allowed.

B. Brake Horsepower Test at Maximum Load

The object of this test is to determine the greatest load the tractor engine will carry on the belt, with the governor set for rated speed and the carburetor set for maximum power. The brake load will be increased until the horsepower developed is the greatest.

The rated speed is to be considered the speed of the motor under load.

This test should begin after the temperature of the cooling fluid has become constant.

The duration of the test will be one hour continuous run, with no change in load or tractor adjustment.

If the speed should change during the test, enough to indicate that conditions had not become constant when the test was started, the test will be repeated with necessary change in load.

C. Brake Horsepower Test at 80 Per Cent of the Maximum Load Recorded in Test B

The object of this test is to show whether or not the engine will carry continuously its rated load on the belt and to show the fuel consumption at the rated load. The governor is to be set to run the engine at rated speed.

The test will also commence after the temperature of the cooling fluid has become constant.

The duration of the test will be two hours continuous run, with no change in load or engine adjustments.

After tests B and C are conducted to the satisfaction of the board of engineers conducting the tests, the nearest whole number to the load carried in test C is to be considered the brake horsepower rating of the tractor.

D. Brake Horsepower Test at Varying Load

The object of this test is to show fuel consumption and governor control when the load varies.

All adjustments are as in test C.

The time and the load are as follows:

10 minutes at rated load (or load carried in test C)
10 minutes at maximum load
10 minutes at no load
10 minutes at one-fourth rated load
10 minutes at one-half rated load
10 minutes at three-fourths rated load

The total running time is one hour and the test is without any stopping of the engine or change of engine adjustments. If the load changes make readjustments necessary, the final report of the test will state that such was the case.

The variation in speed from the rated speed shall not be more than 10 per cent.

E. Nebraska Results May Be Accepted

In lieu of tests A, B, C, and D, the board of engineers may accept the results of similar tests on the same model of tractor conducted by and under the rules of the Nebraska tractor tests. The brake horsepower rating, however, is to be only 80 per cent of the maximum horsepower determined by the Nebraska tractor tests.

METHOD OF TESTING

It is recommended by the American Society of Agricultural Engineers that the brake test outlined above be conducted by one or more disinterested engineers. These engineers to be selected from full membership in the following societies:

American Society of Agricultural Engineers
Society of Automotive Engineers
American Society of Mechanical Engineers

The engineer or engineers conducting the tests must first be approved by the Council of the American Society of Agricultural Engineers.

Reports of the tests must be signed by all of the engineers conducting the test and the signed reports sent to the secretary of the National Association of Farm Equipment Manufacturers to be placed on file, subject to inspection by anyone interested in them. Duplicates are to be furnished the secretary of the American Society of Agricultural Engineers and the manufacturers of the tractors tested.

Members of the engineering faculties of the state agricultural colleges and universities are also eligible to serve as members of the board of engineers.

These tests are to be conducted on one or more tractors picked at random by the disinterested engineers conducting the test from the stock run of tractors from the factory. If more than one tractor is tested the averages of all tests are to be used in determining the brake horsepower rating.

All tests will be made on the *lowest grade* of fuel which the tractor manufacturer recommends for this particular tractor, these fuels to be purchased in the open market and to consist of the low grades of either kerosene or gasoline sold in the locality. All fuels to be tested by the board of engineers.

Manufacturers must specify the kinds and grades of lubricants to be used in the different parts of the tractors tested.

Tractor manufacturers will furnish an ample number of trained operators with their tractors while they are being tested.

The manufacturer will be required to furnish operators during the entire series of tests, the board of engineers to act in a supervisory capacity and to take all readings and compile results.

All belt tests must be made with an electric dynamometer, an accurately tested Prony brake, or other power-measuring device approved by the board of engineers. If a Prony brake is used, allowance must be made in the results for the power needed to drive the brake.

The quantity of fuel used in each part of the test will be determined by weight and the quantity reduced to gallons at 60 degrees Fahrenheit. For brake tests a tank will be placed on a scale and set at the same height as the tank on the tractor. Fuel will be drawn from this tank on the scale during

*Report of the Subcommittee on Tractor Ratings presented at the fifteenth annual meeting of the American Society of Agricultural Engineers, Chicago, December 27, 28, and 29, 1921.

the tests. The fuel tank shall contain at least two gallons of fuel during any part of the tests.

The quantity of oil used is to be determined by the standard gallon, quart, or pint measure, or by weight if more convenient.

The quantity of water used in the radiator and cooling system is to be determined by measuring the height of the water at the beginning of the test and filling to the same level at the end of the test, weighing or measuring the water added. If necessary in order to secure accurate results, the water added will be heated to the same temperature as the water in the radiator or tank.

The quantity of water used in the carburetor, where such water is used for fuel purposes, is to be determined by weight. A tank is to be placed on a scale and set at the same height as the tank on the tractor. Water will be drawn from this tank on the scale during the test. The water tank shall contain at least two gallons of water during any part of that test.

These tests may be conducted at any place which meets the approval of both the manufacturer and the board of engineers conducting the tests.

DRAWBAR RATING

In the drawbar rating the manufacturer is to be given the choice of either of the following two methods:

(a) The drawbar rating to be 60 per cent of the brake horsepower rating determined by test C.

(b) A maximum drawbar test conducted by and under the rules of the Nebraska tractor tests. The drawbar rating is to be 80 per cent of the maximum drawbar horsepower developed in this test.

Respectfully submitted,

SUBCOMMITTEE ON TRACTOR RATINGS

Geo. W. Iverson, Chairman	F. N. G. Kranich
K. J. T. Ekblaw	O. W. Sjogren
D. L. Arnold	L. R. Van Valkenburg
D. P. Davies	F. M. White
	H. H. Bates

DISCUSSION

MR. JOHNSON: It is desirable that we have a method of rating tractors that will be accepted by the purchaser, the manufacturer and state legislators, but after working on it several years it seems to me it is going to be a pretty hard thing to obtain. I wondered why the fuel consumption entered into the proposed method. Is it proposed to make that a part of the rating, or just the test?

MR. IVERSON: That is to be a part of the finished report; it does not enter into the rating at all.

MR. JOHNSON: After testing engines for a number of years, and you talk to me about taking a tractor out of stock at random and running an official test, I could not possibly say that would be satisfactory. For instance, well-built engines that will develop 35 horsepower, taken out of stock, may show a mechanical loss several times that which it will show after it is properly run in. I don't think any method of testing tractors that provides for picking them out of stock means anything to anyone, either the purchaser or the manufacturer, or anyone else. If it is possible to find a means of testing tractors that will be satisfactory it will be a fine thing, but it is a big problem on account of so many variables entering into the test.

MR. IVERSON: I want to explain how the proposed drawbar rating was devised. The main reason why you need a drawbar rating is to determine in a relative way how many plows the tractor will pull. The farmer does not care whether you have forty horsepower or sixty if it will pull the three plows under the conditions he has. The main drawback to many of the ratings given has been that they have misled the farmer. He has been told that he could pull three plows when he could actually pull only two, so the disadvantage of the drawbar ratings in the past has been overrating, not underrating. We wanted to be sure, so far as we possibly could, that any rating that we give would be conservative. That is the reason we took 60 per cent.

Now if a manufacturer feels that his tractor has more efficiency the only means of finding it out is to test it in some way, and that test ought to be conducted so it would be comparable with another test, and the only way it would be at all comparable would be to confine it to one place. We already have that place at the University of Nebraska. The reason we put in that test as the second choice is for the manufacturer who feels that his tractor has more efficiency than allowed by the 60 per cent.

The Engineers Must Take a Hand

By Mortimer E. Cooley
President, Federated American Engineering Societies

THE engineer must dream of a vast public service, from which he will receive no direct profit whatever. He must realize the benefit that will come to the public and himself from the recognition of the gigantic body of engineering service as a force in the country's life.

He must place his knowledge at the service of the public in the hundreds of fights between it and the public utilities corporations. At present the public interests are being played with like dice on a table. Each side thinks the other the biggest liar on earth. I know one man who made $16,000 criticizing a little piece of work I did.

The engineer must take a hand in the reorganization of the government departments, already started by the Federation. He must see that laws licensing or registering engineers are standardized, so that a licensed engineer in Massachusetts may practice in Oregon. He must foster the campaign to save the country thousands of dollars by having it mapped to show contours, elevations and such. He should aid in the fight to pay patent office employees enough so that efficient men may be obtained.

Think what the engineer can do for the public benefit by seeing to it that provisions are made by states and counties for the adequate maintenance of the highway systems now being begun all over the country. And does the engineer realize that at the end of sixty-seven years we won't have a stick of timber in this country—that we shall be subject to the same ravaging floods China suffers now? The engineer must preach the gospel of reforestation.

The engineers' minds have formed a region to themselves. Now they must admit the public to that area; better, they must take the area to the public.

Wearing Tests of Plowshares

A WEARING test of manganese steel, soft center steel, and chilled cast iron plowshares has been made by the agricultural-engineering division of the California agricultural experiment station. One share of each material was used on the same three-bottom tractor gang plow positions as front, middle, or rear, being interchanged after approximately one-third of each test had been run. Data taken included weights, dimensions, and outline tracings of landside portions and of the bottom of the point of each share. A. H. Hoffman (Mem. A. S. A. E.) reports that the least wear was shown by the chilled cast iron shares, slightly more by the soft center steel, and considerably more by the maganese steel. The manganese steel had been annealed at the factory. The test is being repeated with the manganese steel shares hardened. Excellent wearing of manganes steel jaws in rock crushers, tractor gears and track links, and dredger machinery has led to the hope that the material might furnish a better plowshare than those ordinarily used.

Research in Agricultural Engineering*

IN THIS report an attempt has been made to summarize the outstanding features of agricultural engineering experimentation, investigation, and research completed or in progress during the past year at the state agricultural experiment stations, certain other state and federal institutions, and certain foreign agricultural and engineering institutions.

Unfortunately certain factors enter into the preparation of such a report which tend to result in the omission of numerous important features and to make absolute accuracy in the statement of certain others quite difficult to attain. This is especially true of cooperative projects where the work has been reported under some department of the station other than the agricultural engineering department. Again many projects are being conducted wholly on state funds and may be omitted from reports to the Office of Experiment Stations. Furthermore, it has been found very difficult in a number of cases to obtain complete or comprehensive statements from the officials of state institutions. All in all numerous omissions and inaccuracies occur in this report.

What appears to be an unfortunate feature of the work in agricultural engineering at the stations this year, as in previous years, is the fact that much of it has been done in departments other than the agricultural engineering department. Obviously, to obtain the best results, such work should be done at least in cooperation with the agricultural engineering department. Again, the total lack or only partial appreciation of the research or the truly investigational viewpoint is still evident in too many cases.

The work in agricultural engineering during the year included the following general subjects: Farm machinery, farm buildings, drainage, irrigation, farm water supply, and sewage disposal, land clearing, materials of construction, and miscellaneous.

One of the more important features of the farm machinery studies during the year seems to have been the work relating to tractors, of which tractor economics comprised a considerable portion. Economic studies were reported from the Illinois, Indiana, Florida, Missouri, Connecticut, Montana, and New York Cornell Stations. In most cases these studies were conducted on state funds and, with one or two exceptions, were handled by departments other than the agricultural engineering department. In view of the fact that somewhat over three hundred different types of tractor are being manufactured and sold in this country today, the question constantly arises as to what of permanent value to agricultural engineers actually results from an analysis of the purely statistical data obtained.

It is believed that this argues the importance of conducting such studies at least on a cooperative basis with agricultural engineers in order that they may be planned and carried out and the results analyzed, with a view to producing basic information of both practical and scientific value. It is to be noted in this connection that the tractor economics studies of the U. S. Department of Agriculture have apparently been placed on such a cooperative basis. These studies, if properly planned and carried out, should yield considerable information upon which to base engineering projects in tractor research.

There seems to be a tendency in the tractor work at some of the stations to formulate what appear to be blanket projects covering a multitude of problems. Of course, conditions and circumstances often influence such cases but nevertheless there is a strong indication of a lack of appreciation of the magnitude of the problem and of the importance of selective judgment in its treatment. A broad subject like tractors which includes a large number of unsolved problems cannot possibly be given comprehensive treatment in one project without a very large personnel and extensive equipment. It would seem better, therefore, to analyze the subject into its important elements and select the most pressing problem, with reference to locality and conditions, for first treatment. The work on this problem should be planned with a certain definite object in view calculated to tie it up with the other tractor problems.

As instances of the growing tendency to exercise analytical and selective judgment in dealing with the tractor problem, attention may well be drawn to the work at the Indiana, Nebraska, Texas, and California stations. The Indiana project might at first glance be considered a mere blanket project since, in addition to the general economic studies, it includes nearly a dozen other definite features. However, this apparent excess volume of the project seems to be the result of an analysis of the tractor situation in the state. There is also evidence that the station has recognized the importance of attacking the elements of the tractor problem in the order of their relative importance, in spite of the volume of its project. This is indicated by the studies on such individual subjects as slippage and drivewheel equipment which has already yielded some significant results. An exhaustive study on this subject was recently completed in Italy and reported by the International Institute of Agriculture at Rome, thus indicating its importance.

While the Nebraska tractor project, operating on state funds, calls for work on tractor testing and rating, and is not considered on the whole as a research project by the Office of Experiment Stations, a large amount of test data has been secured which have been subjected to analysis. Some of these analyses were submitted to the Research Committee for consideration and comment and it was found that on tentative interpretation they yielded certain more or less new basic relations and principles of a general nature, of course, which, if further investigated, it is believed will materially influence standardization in both the design and rating of tractors. It has been recommended that these analyses be made the basis for the formulation of certain definite research projects on tractors which can not be discussed in detail here. There is every reason to believe that the tractor testing work as now carried on, if properly supplemented by careful and exhaustive analysis, intelligent interpretation, and special investigation where necessary should be productive of many new basic principles tending to standardize tractor design.

The California project, while somewhat less comprehensive, is organized more specifically upon research lines with certain definite problems in view. Among these, the problem of motor lubrication has received rather exhaustive preliminary analytical study as a subject of prime importance, and provisions have been proposed to carry the work to completion. A further result of the analysis of the tractor problem at the California station is a project on methods of cleaning the intake air of tractor motors which was submitted to the Research Committee as a study of prime importance. This project has been the subject of considerable discussion by the Committee, and it is hoped that it will serve to standardize all future similar studies.

As a result of an analysis of the tractor problem in Texas, Prof. Scoates has proposed a comprehensive project on tractor engine lubrication to the Research Committee as one of

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prime importance. This involves a cooperative study with the chemistry department on motor oils and is to be put into operation shortly at the station. This project is of considerable interest in view of similar work at the Iowa and California stations, and the Committee has subjected it to considerable analytical study with a view to making it a standard for similar studies. A striking instance of exhaustive research on this important subject which should be considered in connection with this project has recently been reported by the Lubricants and Lubrication Inquiry Committee of the Advisory Council of the Department of Scientific and Industrial Research of Great Britain. This study dealt with the lubrication of both internal-combustion engines and machinery, and included work with all kinds of lubricating oils comprising both mineral and vegetable oils and mixtures thereof and a number of so-called technical mixtures prepared in the laboratory. Different combinations of gears and gearing were studied. The indications are that for practical purposes a certain amount of deflocculated graphite in mineral engine oils seems to increase their efficiency. The best manner of incorporation of the graphite is a subject for further study.

No reports of other comprehensive tractor studies at the state stations have been received during the year. It is known that considerable tractor work is being done, but reasonable doubt exists as to the existence of any number of well-organized projects of study.

The subject of fuels for internal-combustion engines has commanded considerable attention this year. The fuel studies conducted by the U. S. Bureau of Standards have included such important features as characteristics, economy, and detonation.

Significant results as to the relation between the phenomenon of detonation or knock and timing have been obtained. The engineering experiment station of the Ohio State University has also reported studies of the flash and burning points of kerosene-gasoline mixtures and on the economical utilization of liquid fuel. The fuels section of the Imperial Motor Transport Conference of Great Britain has also conducted some important researches on alcohol as an internal-combustion engine fuel. The work has included especially a comparison of alcohol with gasoline and other volatile hydrocarbons and a study of the effects of mixing alcohol with volatile fuels. The indications are that the lower calorific value of alcohol is almost compensated for by the greater compression at which it can be used, and this property of high ignition temperature under compression is hardly altered by admixture with 20 per cent of benzine or a gasoline itself. The French and Belgian studies of palm oil as a motor fuel in the tropics during the past year are significant and indicate the existence of a new and very effective fuel for tropical use in this relatively cheap and abundant oil.

General tractor studies were conducted during the year in Belgium, France, Sweden, Denmark, South Africa, England, and the colonial possessions and protectorates of Ceylon, Tunis, Java, and India. The Belgian studies were essenthe basis of technical considerations. The work in the colonies and protectorates was usually of a special comparatially of an economic nature but were planned largely upon tive nature and can not be classed as a very high order of research.

Work along other farm machinery lines has been varied. A project on fertilizer distributing equipment has been inaugurated at the Alabama station. This seems to have developed into a very important and somewhat pressing problem in some localities. In this connection it is to be noted that the Deutsche Land-wirtschafts-Gesellschaft of Germany has recently completed a very exhaustive study of fertilizer distributors under the intensive conditions of cultivation in vogue in Germany. Dust prevention when handling dusty fertilizers was an important feature considered. A significant preliminary finding was that no single machine is available on the market which meets all of the conditions imposed. The work naturally proceeded into an analysis of what a fertilizer distributor should accomplish under such conditions, and on this basis a study was planned and conducted which yielded the basic principles which govern the design and construction of the fertilizer distributors desired. These are to be placed in the hands of farm equipment manufacturers when the final interpretation is complete. This work indicates the opportunities existing for the development and standardization of machinery of this kind. Thus the possibility is evident that the Alabama project on the subject may be one of far-reaching importance. While its details are not available it is hoped that the plan of procedure has been organized so that the study will not stop with a mere comparison of existing machines.

Studies on the power requirements of farm implements, particularly tillage implements, have been conducted at the New York Cornell, Wisconsin, Nebraska, Montana, Iowa, and Missouri stations. With one exception, these projects have been operating on research funds and all seem to embody certain research principles. In some cases, notably Iowa, Missouri, and Nebraska, the studies are becoming quite comprehensive. This subject was deemed of such importance by the Nebraska Station that a project on the power requirements of tillage machinery has been submitted to the Research Committee which it is hoped will not only tend to standardize studies of this type but will tend to stabilize and standardize the design of certain tillage machines.

The Iowa station has a voluminous farm machinery project in force which includes among other things studies on corn picker-huskers, silage harvesters, small threshers, small silage cutters, grain shockers, shock movers, and silage packers. To the casual observer it might appear that a great deal of the work under projects of this type would consist merely of miscellaneous testing, and in the past this has probably been true to a considerable extent. But there is now a growing tendency to organize these studies so that on careful analysis the data obtained is susceptible of interpretation which invariably uncovers numerous new and unsuspected basic relations as well as certain misconceptions and omissions. While the work at Iowa on this project, covering so many miscellaneous machinery subjects, has been apparently for the most part conducted on research funds, some of it is believed to be worthy of more careful analysis and planning from the research standpoint than apparently has heretofore been accorded it.

With this in view two projects of proposed research have been submitted to the Research Committee for criticism and comment. One of these is a study of corn planters and corn planting methods adapted to multiple-row cultivation, the purpose of which seems to be the development of corn planters and cultivation along efficiency lines. It may be said in this connection that the development of farm machinery along efficiency lines seems to be one of the most popular and pressing subjects in agricultural engineering at this time, especially in the Middle West. The other project submitted to the Committee is on the power requirements of silage blowers. An analysis of this project by the Committee showed that the subject includes a number of unsolved and very important problems relating to the efficient use of silage blowers.

In this connection a report of similar work conducted at a leading British University was recently presented to the Royal Society of Arts of Great Britain. The studies dealt specifically with pneumatic elevators in theory and practice, and were limited to suction types. The experiments were conducted with grain, husks, and other materials, and in-

cluded determinations of pressure of air on grain and other materials, grain velocity, efficiencies of vertical conveyors, and efficiencies of nozzles. Mathematical expressions were derived from the interpretation of the data obtained which express the basic principles and relations governing the design and operation of such elevators. This work should be a valuable aid in work similar to that planned at the Iowa station.

The work at the National University of Buenos Aires on hay and silage cutters should also be important in this connection. These studies have been conducted for some time with a view to developing the most rational type of knife for hay and silage cutting, and have so far indicated the superiority of spiral-shaped knives to straight knives. The necessity of establishing a definite relation between the geometric form of the knife, a convenient peripheral speed, and the weight of the frame also seems evident. Studies on corn-harvesting machinery at the University have also been in progress, and have resulted in the development of two types adapted for green and dry corn, respectively.

A comparative study of horse and motor cultivation is in progress at the Mississippi station. While this does not sound like research, it is understood to be operating on research funds, and so must include at least some of the elements of research.

An unique and very interesting project has been apparently finished at the Montana station, dealing with the development of power by use of bulls in a treadmill. Some of the features of this project, such as the development of an automatic slapper, are very amusing, but yet they involve the use of scientific principles, and the project on the whole seems to be a well-planned and executed piece of cooperative scientific work.

A distinct contribution to the causes of and remedies for thresher explosions has resulted from recent studies by the U. S. Bureau of Chemistry on matters relating to the accumulation and redistribution of static electricity in threshing machines. In all cases a continual marked difference in potential was established between the earth and the different parts of the machine studied. Several steel machines showed, as individual units, a greater potential than the earth. The indications are that under favorable conditions the cylinder concaves and grain pan of a thresher will become electrified to a greater extent than other parts of the machine, resulting in the occurrence of sparks during the restoration of normal static balance.

Considerable work has been reported as being in progress during the year on the subject of farm buildings and equipment, including heating and ventilating. The Iowa and Indiana stations appear to have been among the leaders in this work as far as amount of work done and number of subjects studied are concerned. Attention is drawn to this matter since, like the Indiana tractor project, the Iowa and Indiana farm building projects cover a large number of subjects, perhaps too many to be effectively covered in one project. On the other hand, the number of these subjects presented is evidence of the exhaustive analysis which has been made of the subject as a whole, and indicates the growing tendency to select and study the more important elements of the subject revealed by such analysis. The Iowa projects cover such matters as farm houses, general farm barns, cattle barns, dairy barns, horse barns, poultry houses, swine houses, sheep sheds, crop storages, granaries, corncribs, smokehouses, manure pits, machinery sheds, garages, power plants, cattle feeding barns and equipment, silos, and ventilation systems. The Indiana project is equally as comprehensive. A study of ventilation systems has also been in progress at the Wisconsin, South Dakota, Minnesota, and New Hampshire stations, and, of course, the classic work on ventilation of the late Dr. Armsby and his associates at the Pennsylvania station is well known to all agricultural engineers. Materials for stable floors have been a subject of special study at the Ohio State University.

Work on silos has also been in progress at the Michigan, Missouri, and Guam stations. In all three cases the work has been supported by research funds. The investigations at Missouri have been planned to study all conditions affecting the use of the silo, including material of the wall, moisture factors, loss of nutrients, and silo capacities. The Michigan studies have resulted in considerable working data on silo capacities.

The subject of poultry houses has been studied at a number of stations but perhaps most systematically at the Kentucky, New Jersey, Oregon, and Washington stations. The New Jersey studies have been especially comprehensive and have constituted a process of gradual elimination of different designs down to certain definite standard types and equipment. The work at the Washington station is also approaching this stage.

Dairy barns and milk houses have received attention at the Wisconsin, Arizona, and Texas stations. The Wisconsin studies have been quite comprehensive, and the work at Arizona has resulted in the development of an adobe milk house. At South Dakota work on farm barns and dairy barns has been reported which has resulted in quite definite standard principles of design for the state. However, insufficient information is available regarding this work to determine its research status.

A striking piece of research has been reported from the Delaware station on sweet potato storage houses. Unfortunately it seems that this work was conducted entirely by the horticultural division. Nevertheless, it has yielded some valuable basic principles affecting the design of sweet potato storage houses in that locality.

The Minnesota station has started a study on the heating and ventilating of farm homes. In this connection it is well to draw attention to the fact that noteworthy research has been reported from Germany on the heat conductivity of building and insulating materials and heat permeability factors of new structures. In addition the University of Illinois engineering experiment station has studied and reported on the emissivity of heat from various surfaces and is continuing the warm-air furnace research work. The Ontario Agricultural College has reported research work on insulating materials, and the American Society of Heating and Ventilating Engineers has reported studies on the transmission of heat through single-frame double windows. All of these studies taken together should be of considerable importance in connection with studies of the heating and ventilating of farm buildings and dwellings. The importance of the subject of ventilation needs no emphasis. The Research Committee has made no attempt to formulate a project of research on ventilation owing to the projects already in existence. However, the importance of the subject of the artificial heating of animal shelters has been looked into, and it is hoped that a project may be organized on that subject.

The Committee has considered no general farm building project for a number of reasons. One is that a number of such projects are already in existence. But the most important reason is that the subject obviously first needs a more thorough analysis by all the different states and a comparison of notes to see just what elements should be attacked first.

It would seem that the time is ripe for further studies of farm houses, with particular reference to the development and use of new materials of construction. In this connection it is to be noted that the Ministry of Agriculture of England has inaugurated a set of studies on the relative values of farm houses made of monolithic concrete, cob, pise de terre or earth rammed between movable forms, timber, and timber

and brick. The main purpose of this work is the development of the use of pise de terre which promises to be a cheap, flexible, and efficient material.

With certain exceptions it is not believed that the drainage work which has been done at the state stations this year as a whole has been of a very high order of research. Of course, the very nature of the subject and general circumstances make it difficult to plan and carry through projects of research. The demand for practical information on the subject seems, however, to have occupied a large part of the time of the men assigned to such work at the stations, and has left relatively little time and funds for research.

In spite of circumstances and conditions tending to discourage research some few noteworthy pieces of work have been done. The cooperative projects in North Carolina on the efficiency of underdrains, run-off from drainage canals, run-off from underdrained land, and action of tile drains on ground water level deserve special mention. These studies seem to have included a special study of soils as a basis for the drainage experiments. Another noteworthy cooperative study is that conducted at the Alabama station on the effect of tile drains in the lime or prairie soils. Two other local cooperative projects have also been inaugurated at the Alabama station on farm drainage and terracing and studies of swamp and overflow conditions. The nature of these studies is not yet available. The Ohio and Minnesota stations are engaged in studies of the depth and spacing of drains, and an interesting study on this subject has just been reported from Germany.

At the Montana station a study is reported as being in progress on different drainage practices followed in the state and their relative effectiveness. This is hardly research, but could be made the basis for such work. The Colorado station seems to be continuing its studies of drainage requirements of crops.

The Oregon station has several projects on the drainage and improvement of wet lands, including "white" lands, greasewood lands, and tide lands. Much of this work involves the removal of excess alkali and the restoration of a fertile structure. Considerable basic data have already been made available from this work. At the California station work is in progress on land drainage by pumping and on the reclamation of certain marsh and alkali lands by drainage.

Work on the drainage of peat and muck soils has been reported from Wisconsin, Minnesota, and Florida. The Wisconsin station has been especially active in this respect. An important feature of this work is the fact established that the settlement of drained peat soils must be considered as an important factor in the design of both tile and open drains. The further reclamation of these soils after drainage is an important complication of this work.

Studies on the cost of trenching, hauling, and laying tile have been reported from Ohio. The Minnesota station has started a correlation of land and crop values with cost of drainage, and has a project in operation on the movement of water in soils. The Kentucky station is engaged in studies of the effect of the initial moisture present on the movement of water in soil. The project at the Missouri station on the investigation of water penetration, evaporation, run-off, and erosion in average Missouri soils should also be mentioned.

Before leaving the subject of drainage, attention should be drawn to a recent study conducted by the Ministry of Agriculture of England on mechanical ditchers for land drainage. The studies so far have been conducted only on a rotating wheel tractor ditcher for digging tile trenches. The significant fact was established that there is little difference between the cost of work by this machine and by hand labor. However, other advantages such as quick completion of work enter in which establish the importance of mechanical ditchers. Work by the Ohio station on the other hand has so far indicated a considerable saving by machine trenching. The same result was obtained in experiments conducted for one year by the North Scotland Agricultural College.

The subject of irrigation is one in which considerable work has been in progress. It has perhaps received more intensive research treatment than any other division of agricultural engineering, and apparently conditions and circumstances have been distinctly favorable for such work. Under the able leadership of the Irrigation Investigations Office of the U. S. Department of Agriculture the work has developed throughout the irrigated West, and the cooperative projects and individual state projects which have been reported in progress are numerous. The majority of these projects have been operating on research funds, which is a very significant fact in itself when considering their research status.

Owing to the large number of such projects in existence of about equal importance, it would be impracticable to attempt to give them any comprehensive review here. However, the California station submitted a very comprehensive project to the Research Committee for consideration on the relation between irrigation head, soil type, and grade in the preparation of land for irrigation, to be conducted at the station. This general subject is already being studied in one form or another at a number of the stations, and seems to be a very important irrigation matter at this time. The Idaho and Oregon stations especially have been interested in such work as has also the Office of Western Irrigation Agriculture of the U. S. Department of Agriculture. It was with the object of attempting to standardize this particular type of study that the project in question was so readily considered by the Committee. It is hoped to make this project somewhat of a standard pattern for such work, although it is realized that this will take time and considerable analytical study.

Attention may also be well drawn to the ground water studies at the Montana, Arizona, Utah, and New Mexico stations, and to the pump irrigation studies at the Nebraska, Montana, Arizona, and Utah stations. The work at the Nebraska, Arizona, and Montana stations, especially on pump irrigation, has been productive of considerable basic working information.

The question of duty of water has been under investigation at the Utah, Idaho, California, New Mexico, Oregon, Montana, and Nebraska stations, especially, and this work is so well known as to need no comment. The U. S. Reclamation Service has also been quite active in this connection.

Numerous alkali land and alkali tolerance studies have also been in progress, notably at the Arizona, California, New Mexico, Idaho, and Utah stations, and the U. S. Department of Agriculture has reported a comprehensive study on the quality of irrigation water in relation to land reclamation. A significant conclusion drawn from this study was that the quality of irrigation water should be judged not only by considering the total quantity of the salts in solution or the proportions of the acid radicals but also the proportion of the sodium to the calcium and magnesium. This is taken to indicate that water to be safe for long-continued irrigation should be relatively rich in calcium and magnesium.

The study of water measurement devices, including current meters and the Venturi flume, at the Colorado station and of weirs at the Montana station should be mentioned, and the evaporation studies at Colorado are reported as being still in operation. Other special studies related to irrigation which have been reported are on the use of concrete pipe in irrigation by the U. S. Department of Agriculture and on conveyance losses of water on irrigation projects by the U. S. Reclamation Service.

The latter study has indicated that 25 per cent is about

the minimum loss that may safely be estimated under favorable conditions and that 50 per cent is sufficiently high for the average well-planned project. It was further shown that concrete linings, on account of their high costs, should be resorted to only after all other means of preventing losses have failed.

Noteworthy foreign work has been reported by the Deutsche Landwirtschafts-Gesellschaft on the spraying of fields with municipal sewage. This work has led to the development of three different types of portable spray irrigation apparatus which may be used in the distribution of clarified and partially clarified municipal sewage, especially in furrow irrigation.

Research on the subjects of farm water supply and sewage disposal has apparently been almost nonexistent during the year according to the information available. There are a few exceptional cases which will be mentioned, but it is believed that the majority of such work that has been done during the year has consisted largely of reproduction and very little of creation. There is ample evidence of the importance of unearthing and establishing some of the basic principles of this subject. The Research Committee hoped to formulate a project of research on some phase of it but has failed to do so.

There have been many more or less well meaning but poorly planned and conducted attempts to get at the fundamentals of the subject. There are a few exceptions, however, which may well be mentioned. The study at the New Jersey station on the biology of sewage disposal is unique and stands practically alone in its class as a research project on farm sewage disposal. Its purpose is to determine how sewage may be disposed of with a reduced amount of water and end products containing waste materials in a commercial form. This is a Hatch fund project and unfortunately, it would seem, is being conducted by the Department of Entomology alone. Here would appear to be a wonderful opportunity for cooperative work on an extremely important subject. In a preliminary study of the biology of the sprinkling sewage filter, it has been found that organisms are present in the gelatinous film of a filter which are similar to those occurring in the soil, and which act in the oxidation of organic nitrogen to inorganic forms. This process seems to be a gradual one, starting in the top layer with the zone of greatest activity in the second layer. Here it seems is a distinct step forward to establish a bridge between the results obtained with large-scale filters and the results desired on small-scale absorption or filter systems. Other biochemical facts were established which should be of the utmost importance in a study of farm sewage disposal.

The work at the Montana station on farm sewage disposal in which at least three methods are being studied is perhaps not so comprehensive in plan as the New Jersey project, but is a more distinctly engineering project. This project has been quite productive of information so far, but it is believed it should be continued to a point where interpretation of the data obtained will yield some definite basic principles. It also is believed that a certain amount of cooperation with the Chemistry Department would add materially to the value of this project. The work at the New York Cornell station on the disposal of creamery sewage and the disposal of domestic sewage by subsurface irrigation should also be mentioned. The latter of these projects apparently has been in operation for some time. The Missouri station has for some time been conducting a project on sanitary equipment for farm homes in which unfortunately it would seem the extension features are apparently being considered at the same time. The U. S. Public Health Service has had a most comprehensive project in operation for some time on the treatment and disposal of creamery wastes. This has been conducted in cooperation with the U. S. Department of Agriculture. The interpretation of results obtained has established numerous basic principles of value. The work at the Minnesota station on farm sewage disposal should also be mentioned. This work indicates the superiority of the rectangular, two-chamber septic tank for certain Minnesota conditions.

The Rothamsted Experimental Station in England has recently reported a remarkable piece of research on the use of straw filters for sewage purification. The indications are that straw when used as a filter gradually removes the nitrogen from the sewage and, as the filter ripens, a straw manure is formed equal in value to the best stable manure. At the same time the sewage is effectively purified. It is concluded that for best results about two pounds of dry straw per person per day is required in the filter. From 20 to 35 days is required for maturity of the straw filter.

Both the Idaho and North Dakota stations have water supply projects. The former consists of a study of the design and installation of farm water supply systems, and does not give outward evidence of carrying the aspects of true research. The latter, however, is a Hatch fund project to determine the suitability of North Dakota waters for drinking and mechanical purposes, and unfortunately is confined to the division of agricultural chemistry.

There are probably other water supply and sewage disposal studies in operation, but these are all which have been reported. It is believed that the time is ripe to get together on this subject with a view to digging out the basic principles involved. It is recommended that future research committees get into touch with the Montana, New York Cornell, and New Jersey stations, the U. S. Public Health Service, and other institutions interested in the subject, with a view to establishing some studies on this subject which will settle the questions relating thereto once and for all.

While the subject of land clearing is an old one, it has developed some new and interesting aspects during the past two or three years, and especially since the signing of the armistice ending the world war. The U. S. Department of Agriculture has shown its interest in the subject by conducting cooperative experiments with the Wisconsin station on the use of explosives in blasting stumps. Salvaged T.N.T. and picric acid have developed into effective explosives for this purpose, as indicated by the Wisconsin experiments. So-called grenade powder and modified versions thereof have also been used with a certain degree of success. The Wisconsin station has also conducted studies on the time of brushing and seeding cut-over land, on the comparative strengths of dynamite required for blasting pine and hardwood stumps on various soil types, and on the comparative value of the different methods employed in the removal of pine and hardwood stumps. A certain amount of similar work has been in progress at the Minnesota, Oregon, and Alabama stations. Of course, a large part of this work consists mainly of comparative experiments. Yet the results are to a certain extent susceptible of analysis and interpretation into basic principles and apparently little more can be asked in view of the nature of the work. The work has resulted in the development of new and improved methods, and it is believed that it can well be carried much further.

Materials of construction as a subject has developed from a minor miscellaneous matter to one of the main divisions of agricultural engineering. Its connection with all other important divisions of agricultural engineering is becoming more and more evident, and its rise to an important division is only a natural result and true indication of progress in the subject as a whole. The preservative treatment of fence posts, timbers, lumber, shingles, and other wooden structural materials has been under investigation at the Alabama, Minnesota, Montana, and Iowa stations especially. The U. S. Department of Agriculture has reported a study of powder post damage to timber and wood products and preventative

measures. These have indicated the effectiveness of kerosene and hot boiled linseed oil as preventative measures against this destructive agency. The American Wood Preservers' Association has derived mathematical formulae showing the penetration of creosote into various sizes of sawed and round timbers, and the German Agricultural Society has conducted an investigation of the fundamental principles of wood conservation in order to get at the root of the matter.

The Minnesota station has reported a comparative study of fence posts and an investigation into the effect of structure, time of cutting, and methods of seasoning of white cedar on the penetration of preservatives. The Ohio station is also engaged in an investigation of the relative durability of fence post timbers, and the Iowa station apparently is continuing its project on roofing materials.

A study has been in progress at the New Jersey station on fungi injurious to paint. In this work the purpose is to determine the species of fungi growing on painted surfaces, the environmental facts and conditions, the injurious effects, the relationship of fungi to paints of different composition, and preventive measures. This is a new and unique study, and would seem to be an outgrowth from or an advance on the comprehensive studies of paints and painting conducted for some years by the North Dakota station and the U. S. Bureau of Standards. The U. S. Reclamation Service has also been engaged in a study of water gas and coal-gas-tar paints for irrigation structures which indicate the superiority of tar paint for submerged metal works.

The Iowa station has been conducting a service study of oils, presumably lubricating oils. The Idaho and Wisconsin stations have studied the design, manufacture, and durability of concrete tile for drainage and irrigation purposes, and the Wyoming station is apparently still engaged in its study on the alkali proofing and the preparation of alkali-proof cements. The cooperative project on the action of alkali on concrete conducted by the U. S. Department of Agriculture, the U. S. Bureau of Standards, and the U. S. Reclamation Service is apparently still in existence. All of these studies seem to indicate that the sulphates are the salts most dangerous to concrete.

The U. S. Department of Agriculture has recently been engaged on a study of the water resistance of treated canvas during continuous exposure to weather. Eighteen different treatments have been tested. The effectiveness of lead oleate and Bermudez asphalt in waterproofing mixtures has been especially indicated. Beeswax is superior to all other hard waxes tested.

The University of Illinois Engineering Experiment station has reported a study on the thermal conductivity and diffusivity of concrete, indicating the relation between the conductivity and diffusivity of concrete, indicating the relation between the conductivity and the proportion of solid material to voids. The Lewis Institute has also reported a study of much interest to agricultural engineers on the effect of storage of cement. Another general study and summary of data is that made by the U. S. Bureau of Standards on strengths and related properties of metals and certain other engineering materials. This work should be of special interest in connection with the development of farm machinery and motors.

As usual there are a few miscellaneous features of agricultural engineering under study which deserve mention. The Alabama station has a project on destructive distillation and one on the effect of grade of terrace and its relation to soil type. The Illinois and Missouri stations and the Ohio State University are also studying the subject of soil erosion and preventive measures. The work at Ohio has recently been centered on such special features as broad base terraces and earth-saving dams. In this convention attention should be directed to a project in soil erosion and preventive measures submitted by the Nebraska station to the Research Committee for consideration. While this project in its original shape was not considered to be research by the Committee, sufficient comment and suggestions were made to serve as a basis for the standardization of projects of this kind. It is believed that soil erosion and terracing studies should be placed upon a definite standard basis with reference to soil type and other conditions, so as to make aimless testing in the subject unnecessary. The importance of the subject needs no emphasis.

Both the Minnesota and Michigan stations have started work on small farm electric light plants. While the status of this work is difficult to determine, it is noticed that the Michigan station has made a brief analysis of the costs which enter into the production of electrical current by gasoline or kerosene. The Ohio State University is also engaged in a study of the effect of oil on the operation of farm electric plants.

Tillage and tillage methods are subjects normally related to the work of agronomists. However, they have such a distinct relation to the development of tillage machinery that it is considered advisable to include them as miscellaneous agricultural engineering matters which are at least of a cooperative nature. In fact, certain cooperative projects are in existence. Studies of tillage and tillage methods have been reported from the South Dakota, North Dakota, North Carolina, Oklahoma, Illinois, Oregon, New York Cornell, South Carolina, Indiana, and Ohio stations. In nearly every case the main point under study is that of depth of tillage. Moisture content seems to be second in importance. The Ohio and North Dakota studies seem to have been especially comprehensive, and the question of subsoiling has been given considerable attention in both projects. The North Dakota results so far are not favorable to the general practice of subsoiling. Recent German experiments on the influence of water content and void space on the ease with which soil may be cultivated have indicated that the common soils are most easily cultivated when they contain hygroscopic moisture only, and that this condition is apparently independent of other physical characteristics. This study would seem to be of particular significance when considering such matters as draft and scouring.

A very important miscellaneous subject which is being studied by the U. S. Department of Agriculture is that of dust explosions. This work, much of which is being conducted in cooperation with the U. S. Bureau of Mines, has yielded some very significant results of far-reaching importance. While it is not practicable to review all these studies here, it is believed that this subject is one to which all agricultural engineers should devote some attention, owing to its close relation to the design of farm structures.

The Research Committee has had a miscellaneous project under consideration submitted by the Iowa station on methods of multiple hitching of horses. This will be a cooperative project with the animal husbandry division. The difficulty of developing a research project on such a subject is obvious, but the purpose is to inject some engineering into multiple hitching and to try to establish some working principles.

From this summary and from the survey made by the Research Committee during the year, four general subjects seem to stand out from the rest as being of prime importance and worthy of immediate and exhaustive research treatment. These are in the order of their importance, as indicated by the survey: (1) Power requirements of farm machinery and its more efficient utilization, (2) farm water supply and sewage disposal, (3) increase of economic efficiency of horse and mechanical power, and (4) determination of standards of design and performance for farm machines and parts thereof.

RESEARCH AND DATA COMMITTEE

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Agricultural Engineering Development

A Review of the Activities and Recent Progress in the Field of Agricultural Engineering Investigation, Experimentation and Research

Edited by **R. W. Trullinger**
Mem. A.S.A.E. Specialist in Rural Engineering, Office of Experiment Stations, U. S. Department of Agriculture

NATIONAL PHYSICAL LABORATORY TRACTION DYNAMOMETER FOR AGRICULTURAL TRACTORS, J. H. Hyde [Engineering (London), 110 (1920), No. 2865, pp. 693, 694, Figs. 7; also in *Agricultural Journal of India,* Calcutta, 16 (1921), No. 4. pp. 417-423, figs. 7.] A dynamometer designed to measure the traction or drawbar pull of the tractors tested at the Lincoln trials in England is described and diagrammatically illustrated. It consists of a cylinder and plunger, the former being attached to the drawbar of the tractor and the latter through links to the plow. The pull on the coupling sets up a pressure in the oil confined in the cylinder, and this pressure is transmitted to a recording pressure gauge by a flexible hydraulic tube.

The connection to the tractor drawbar is made in such a manner that the cylinder cannot rotate, but the opposite end of the dynamometer is provided with a swivel attachment for the plow.

The recording instrument is mounted on a two-wheeled carriage which is towed by the tractor, a suitable hitch being made to prevent damage to the connecting hydraulic tube.

THE COST AND UTILIZATION OF POWER ON FARMS WHERE TRACTORS ARE OWNED, H. R. Tolley and L. A. Reynoldson [U. S. Dept. Agr. Bul. Washington 997 (1921), pp. 61, figs. 14.] This bulletin presents the results of the first of a series of investigations which have been planned by the committee on farm power appointed by the Secretary of Agriculture to represent the Bureau of Public Roads, the Office of Farm Management and Farm Economics, and the Bureau of Animal Industry, in a cooperative study of all phases of the farm-power problem. This investigation dealt with the cost and utilization of power on 286 representative farms where tractors are owned in Ohio, Indiana, and Illinois during 1920.

The average size of the farms visited was 258 acres. Two-plow tractors were owned on 174 of the 286 farms, three-plow tractors on 104, and four-plow tractors on 6 farms. One farmer owned a one-plow machine and one farmer owned a five-plow machine. Two-plow machines were found on 75 per cent of the farms with less than 160 crop acres and on 53 per cent of those with 160 or more crop acres.

One hundred and six of the tractors had been in use one year, 100 one and a half or two years, 49 two and a half or three years, and 31 had been in use more than three years. On the average each tractor was used for 30.8 full days during the year covered by the investigation. Of this period 23.5 days were devoted to drawbar work on the home farm, 2.7 days to belt work, and 4.6 days to custom work. Of the 286 tractors 73 did less than 20 days work during the year and 26 did 50 or more days work.

On the average each farm had 6.8 head of work stock at the time of the survey, and their value was estimated at $144 per head. In all, the 286 farms had 1,878 head of work stock and 111 colts less than one year old. The average number of full days work per year for all farms was 68.6. On 20 of the farms the work stock did less than 40 full days' work each, and on 27 they did 100 or more days' work per year.

The tractors did 85 per cent of the plowing on these farms, 73 per cent of the disking, 43 per cent of the harrowing, rolling, planking, and packing, 41 per cent of the grain cutting, and 15 per cent of the loading and hauling of hay. On the average the two-plow tractors saved 25 to 30 days of man labor and the three-plow tractor 30 to 35 days required for drawbar work during the year on these farms.

The average net cost per head of keeping work stock on these farms for the year ended October 31, 1920, was $159, and the average cost per farm was $1,076. The average cost per day of horse labor for the year was $2.43. The average first cost of the two-plow tractors was $972, of the three-plow tractors $1,354, and of all tractors $1,140. The average amount spent for equipment, mostly plows and disks, for use with tractors was $343. The average value of the horse-drawn implements disposed of after the purchase of the tractors was $12.

The annual depreciation of the two-plow tractors amounted to $164, and of the three-plow $217. The annual cost of repairs was $39 for both the two-plow and the three-plow sizes. The tractors were out of commission when needed on an everage of about two days during the year. A little over 50 per cent were never out of commission when needed, and about one in seven were out of commission five days or more.

The fuel consumption per day for the two-plow tractors varied from about 18 gallons for fall plowing to about eleven gallons for drawing the hay loader. For the three-plow tractors it varied from 23 gallons for plowing to fifteen gallons for drawing the hay loader. The two-plow tractors covered 6.6 acres per day in spring plowing and the three-plow machines 8.6 acres. The quantity of fuel required per acre was 2.7 gallons for each size.

The average cost per acre of power for the plowing done with two-plow tractors was about $2 and with the three-plow about $2.20. The cost of power for the plowing done with horses on these farms was about $2.90 per acre. For most of the other operations the cost of power furnished by horses during the year of the investigation was slightly less than that furnished by tractors. The average cost per day of two-plow tractors for drawbar work on the home farm was about $12.67, and of three-plow tractors about $17.73. The total cost of power furnished by the tractors for drawbar work at home during the year averaged $341.

Nine of the farms started operations with tractors. No change occurred in the size of 172 farms after the tractors were purchased, 81 were increased in size, and 24 were decreased.

On the 172 farms where no change in acreage occurred 44 did not reduce the number of work stock, 62 disposed of one or two head, 43 disposed of three or four head, and 23 of more than four head. On these 172 farms one horse was kept for each 28 acres before the purchase of tractors, and at the time of the survey there was one horse for each 37.7 acres.

For all the farms an average of one horse was kept for each 27.6 acres before the purchase of tractors, and there was one for each 37.9 acres at the time of the investigation.

The cultivation of corn was the operation requiring the greatest amount of horse labor in the shortest time on most of these farms. However, on only 105 of the 286 farms were all the work stock used for cultivation, and on only 38 of the remainder were they all used for any other one operation. On one-half of the farms the work stock were not all used for any one operation.

"The facts that on 20 of the farms the work stock did less than 40 days of work per head during the year and that on half of the farms they were not all used for any single operation indicate that the greatest possible use was not being made of the available power represented by the horses. . . .

"The average annual cost of power for the drawbar work on the home farm which was done with tractors was equal to the cost of keeping 2.1 head of work stock, and this is practically the average number displaced per farm. On the basis of present prices, however, the cost of keeping work stock has declined considerably more than the cost of operating tractors.

"Since, during the year covered by the investigation, the cost of power on the average farm was no greater than if it had all been furnished by horses, any saving in man-labor costs, any gain due to getting a larger amount of work done in a given time, and possibly other advantages connected with the use of tractors which can not be measured directly in dollars and cents, might be considered clear profit. On many of the farms, however, where there was no change in acreage, and where no work stock was displaced it is doubtful if such gains were great enough to balance the cost of operating the tractors."

THE ECONOMICAL UTILIZATION OF LIQUID FUEL, C. A. Norman [Ohio State University, Engineering Experiment Station Bulletin 19 (1921), Columbus, pp. VII + 206, pl. 1. figs. 33.] The purpose of this bulletin is to review the liquid fuel situation in the United States as it has developed in the last few years, and to ascertain as far as possible (1) what the available petroleum resources of the country are, (2) what substitutes for petroleum have been proposed, (3) what the main reasons are for the shortages experienced, and (4) what possibilities there are for relieving these shortages by economy and care in production and use of petroleum and by the systematic development of substitutes or new resources. The possibilities of economy as discussed are described almost entirely from the fuel users' point of view, especially from the point of view of possible improvements in the economy of the engines used. The results of comparatively recent experiments and investigations on this latter point are summarized as simply and briefly as possible, and explanations are given of the methods of operation and designs leading to improved economy. In all this discussion little original research by the author is presented. The bulletin is rather a compilation of references and information scattered over a number of years and in a variety of periodicals. In addition, there are set forth also the results of a few investigations, mainly of a somewhat theoretically scientific nature, which have been undertaken by the author in order to clear up certain points in connection with engine performance. An entropy chart, to be used for analysis and computation of combustion-engine processes, is an addition to the bulletin.

Part 1 deals with the oil fuel situation. The conclusions drawn are that: (1) The domestic production of petroleum in the United States fails to meet the domestic demand. The shortage is increasing and is mainly made up by imports. (2) The main reason for the shortage is the ever-increasing consumption of gasoline by automobiles. Automobile engines operate mostly at reduced load and are very inefficient at such load. (3) Alcohol and benzol deserve attention as substitutes for gasoline, but there is little prospect of producing these substitutes, at least in the near future, in quantities rendering them of other than secondary importance in relieving the automotive fuel shortage. (4) Kerosene is not available in quantities sufficient to make it a great source of relief could the engines be made to handle it. (5) The marine and railroad demands make serious inroads on the amount of fuel oil available for automotive purposes. Yet, by most efficient use of fuel oil for every purpose and by eliminating entirely the consumption of fuel oil where coal will answer notable quantities of fuel oil may be made available. To make this fuel oil adaptable to automotive engines either the fuel oil must be converted to lighter oils by cracking or chemical treatment or oil burning engines must be introduced. Developments along both lines have begun. The so-called injection type of engine is of especial interest as it is now the most economical engine in existence and is especially distinguished by economy at reduced load. (6) Shale oil promises relief in the shortage of oil fuel generally. It is present in quantities sufficient for generations. In some places at least it contains gasoline in considerable quantities. Developments for shale oil production on a larger scale seem to have started.

Part 2 deals with fuel utilization in internal-combustion engines. The nature of fuel, of combustion, and of the heat value of fuel is explained and the heat values and air requirements for a number of fuels are given. The function of expansion in converting combustion heat into power is then considered and the necessity for early completion of the combustion and of maximum possible expansion for good fuel utilization is stressed. It is emphasized that compression is of importance to fuel economy only by enabling expansion and it is pointed out that the fuel economy of Diesel engines is better at reduced load than at full load because the expansion at reduced load is greater than at full load. The variation in mixture requirements of present-day carbureting engines for best economy is discussed. The evil effects of the burnt residue on the fuel economy of throttling carbureting engines at reduced load is pointed out, and various means proposed for overcoming these effects are referred to. The progress of combustion is considered, likewise the nature of knock and the methods of overcoming knock. The difficulties resulting from poor evaporation and distribution of the fuel are taken up and various methods of fuel conversion and charge heating are scrutinized. The influence of friction losses on economy at reduced loads forms the subject of one article, the influence of vehicle speed and gear ratio that of another.

It is concluded that the causes of inefficiency of the present-day carbureting engine are: (1) Difficulties of carburetion and of distribution of the mixture to the various engine cylinders with present-day fuels. (2) Preignition and knocking troubles, making difficult the introduction of compressions sufficient to give economies comparable to that of injection engines. (3) Difficulty in securing good ignition and power with sufficient air excess to give complete combustion. (4) Charge dilution and combustion delayed by the burnt residue—a trouble accentuated by the large clearance volume necessary to avoid knock, and by the throttling method of governing. (5) The general operation of automobile engines at reduced load, at which the troubles in groups (3) and (4) become especially serious.

Part 3 is a scientific discussion of combustion-engine processes, and contains articles on the passage of gas through a throttle valve, cooling by the charge, the evaporation temperatures of liquid fuel mixtures, effect of charge heating on engine output, the heat development in combustion engines, entropy chart, and efficiencies attainable by internal-combustion engines. The following conclusions are drawn:

The throttling of a gas produces no temperature drop. The end temperature of compression should be the same in a throttled as in an unthrottled engine. If knock is relieved by throttling, then knock is dependent on the pressure attained rather than on the temperature. The evaporation of the charge is capable of producing a cooling effect amounting to 50 or 60 degrees Fahrenheit if the evaporation is complete. This cooling effect is naturally reduced by the imperfect evaporation of present-day fuels. It may be masked by heat from the engine parts. Experiments on a truck and tractor engine show it, however, when the air heating is at its maximum, to be of quite the magnitude computed.

Moisture will not condense out of atmospheric air, even if the temperature of the air is much below the boiling point of water under atmospheric pressure. The amount of vapor that air can absorb and keep evaporated depends on the temperature of the air, the pressure of the vapor in the air, and the boiling point of the vapor under this pressure. For perfect evaporation of present-day gasoline a mixture temperature of about 110 to 130 degrees Fahrenheit is necessary, while for kerosene the temperature must be raised somewhat over 200 degrees.

Charge heating reduces the ratio of the absolute temperature after combustion to the absolute temperature before combustion, and hence reduces the pressure rise. The heats of reaction vary both with the temperature and the pressure, but with the possible exception of the combustion of carbon to carbon monoxid, the variation is not too great to allow the use of average values for practical calculations. Dissociation plays an important part in limiting the maximum temperatures attained in all engines running on mixtures rich enough to be fired in a carbureting engine, but yet admits of momentary temperatures above 4,000 degrees. The heat development is greater with mixtures containing the theoretical quantity of air and is less both for over-rich and over-lean mixtures.

"If the enormous expansion ratios common in steam turbines were possible in internal-combustion, then this class of engines might also in theory turn perhaps 75 per cent of the heat energy into power. As such expansions are not manageable with present types of engines, even ideally perfect engines of this kind could attain only very much lower heat utilizations. . . ."

In fact, the margin of possible improvement of present-day engines at their best is less than one might expect. For this reason the desirability of maintaining a receptive attitude towards possible new types of prime movers is emphasized.

POULTRY HOUSES, W. F. Shoppe [Montana Station, Circulation 100 (1921), pp. 23, figs. 9.] Brief information, drawings, and bills of material for poultry houses which have been found adapted for Montana conditions are presented.

It is the author's opinion that environmental conditions are either directly or indirectly responsible for most of the diseased conditions of poultry. Poultry houses should, therefore, provide for an abundance of sunshine and fresh air.

For Montana conditions a wide house has been found to be preferable to a narrow one, since it places the roosts farther from the openings in the front and the birds are less affected by outside changes in temperature. It is considered advisable to sheathe houses on the inside to give extra protection during extremely cold weather, and to sheathe them overhead in order to cut down the air space. The combination curtain and glass front house has proved very satisfactory in many sections of the state. It provides good ventilation, abundance of sunshine, does not allow a draft to strike directly on the birds, and is to be preferred to the open-front house which has no glass in the front.

AN INVESTIGATION OF THE FATIGUE OF METALS, H. F. Moore and J. B. Kommers [Illinois University Engineering Experiment Station Bulletin, Urbana, 124 (1921), pp. 185, figs. 46.] Studies of the properties of ferrous metals such as are used in the moving parts of machinery of varying chemical and physical composition to determine especially the influence of repeated stress and reversal of stress upon fatigue are reported.

For the metals tested under reversed stress a well-defined critical stress was observed at which the relation between unit stress and the number of reversals necessary to cause failure changed markedly. Below this critical stress the metals withstood 100,000,000 reversals of stress, and, so far as can be predicted from test results, would have withstood an indefinite number of such reversals. The name endurance limit has been given to this critical stress.

In the reconnaissance tests made in the field of ferrous metals, no simple relation was found between the endurance limit and the elastic limit, however determined. The ultimate tensile strength seemed to be a better index of the endurance limit under reversed stress than was the elastic limit. The Brinell hardness test seemed to furnish a still better index of the endurance limit. Elastic limits determined from compression tests and torsion tests gave no better index than did those from tension tests.

The single-blow impact tests (Charpy tests) and the repeated-impact tests did not furnish a reliable index for the endurance limit under reversed stress of the ferrous metals tested. Accelerated or short-time tests of metals under repeated stress, using high stresses and consequent small numbers of repetitions to cause failure, are not considered reliable as indexes of the ability of metal to withstand millions of repetitions of low stress. The endurance limit for the ferrous metals tested could be predicted with a good degree of accuracy by the measurement of rise of temperature under reversed stress applied for a few minutes.

Abrupt changes of outline of specimens subjected to repeated stress greatly lowered their resistance. Cracks, nicks, and grooves caused in machine parts by wear, by accidental blows, by accidental heavy overload, or by improper heat treatment may cause such abrupt change of outline. Shoulders with short-radius fillets are a marked source of weakness. Poor surface finish on specimens subjected to reversed stress was found to be a source of weakness. This weakness may be explained by the formation of cracks due to localized stress at the bottom of scratches or tool marks.

Stress above the endurance limits, due either to a heavy overload applied a few times or to a light overload applied some thousands of times, was found to reduce somewhat the endurance limit of two ferrous metals tested. In none of the ferrous metals tested did the endurance limit under completely reversed stress fall below 36 per cent of the ultimate tensile strength, for only one metal did it fall below 40 per cent, while for several metals it was more than 50 per cent. However, these metals were to a high degree free from inclusions or other internal defects. The specimens had no abrupt changes of outline and had a good surface finish.

The influence of subjecting steel to a stress beyond the yield point was greater on the static elastic tensile strength than on the endurance limit, although some increase was observed for 0.18 carbon steel with polished surface after being stretched well beyond the yield point. Annealing of commercial cold drawn screw stock was found to lower its endurance limit somewhat less than it did its static elastic strength.

The results as a whole are taken to indicate the effectiveness of proper heat treatment in raising the endurance limit of the ferrous metals tested. Four appendixes are included.

A. S. A. E. and Related Activities

A. S. A. E. Standards Work for 1922

DURING this year the principal aim of the A. S. A. E. Standards Committee is to complete some of the work that has already been started. In the case of left-hand-plow investigations for example, which the Society was asked to undertake by the plow and tillage implement department of the National Association of Farm Equipment Manufacturers, it is proposed to complete this investigation this year and report definite recommendations with regard to the left-hand plow.

The investigation as to the comparative merits of round blades and cutaway blades for disk harrows has progressed satisfactorily, and with the additional field work that will be carried on this year it is anticipated that sufficient data will be available for the Standards Committee to make definite recommendations with regard to the two types of disk harrows.

Work was started more than two years ago on the standardization of barn equipment, particularly with reference to a standard manger form and the rating of sizes and capacities for litter carriers. It is planned to complete this work some time during the coming year.

At the last annual meeting of the Society in December a standard code for testing tractors was presented. This is at present in the hands of a subcommittee directly in charge of the work and an attempt is being made to eliminate the objections that have been offered.

A subcommittee has been appointed to canvass the situation at the various state agricultural colleges with respect to the agricultural-engineering courses that are now being offered to agricultural students, the purpose of which is to find out if it appears desirable to attempt standardization in this field of activities.

College Section Program

ACCORDING to Prof. Daniels Scoates, head of the department of agricultural engineering at A & M College of Texas, and chairman of the College Section of this Society, the program for college section activities during 1922 is well under way. The College Section is one of the live sections of the Society and has made substantial progress in the comparatively short time that it has been organized.

Prof. F. W. Ives, of Ohio State University, is chairman of the extension committee of the Section and is directing important activities looking into the question of perfecting a uniform code of procedure in the matter of follow-up work in extension projects. There is great need for extension work in agricultural engineering, and the College Section is alive to the necessity and opportunity of accomplishing something in this direction.

An important activity of this section is under the direction of Prof. H. H. Musselman, of Michigan Agricultural College, who is chairman of a committee to compile a teachers' directory, which includes a list of all the agricultural engineering instructors and professors and their specialties. This work when completed will be a very valuable help to all members of the College Section.

Research is one of the more important things receiving the attention of the Society at the present time and one in which the College Section is particularly interested. The need for research in agricultural engineering is very great indeed. This activity of the College Section is under the able direction of Prof. J. B. Davidson, of the Iowa State College, whose committee is now at work carrying out an extensive program in conjunction with the regular Research Committee of the Society which promises to place research work in agricultural engineering on a sound, progressive basis.

Another much needed and important work undertaken by the College Section is the standardization of course in agricultural engineering. Prof. W. J. Gilmore, of Oregon Agricultural College, is chairman of the committee on standardization of courses of this Section, the purpose of which committee is to determine the possibility of standardizing some of the courses in agricultural engineering in the various state agricultural colleges. The committee plans that the particular phase of the work which they will specialize on this year is in connection with courses on farm motors.

Program of the Farm Structures Section

THE performance of the Farm Structures Section has been particularly conspicuous during the past two years because of the amount of good work that has been accomplished in the direction of farm buildings development. W. G. Kaiser, chairman of the Section, reports that the plans of the various committees are well under way and give promise of some very effective work during this year.

It is the plan of the Committee on Farm Sanitation, of which E. W. Lehmann of the University of Illinois is chairman, to continue its work along the same general lines of last year, devoting a certain amount of attention to general subjects such as drainage, effective sanitary conditions, the problem of water supply, sewage disposal, and farm plumbing.

The Committee on Farm Building Design, of which W. A. Foster, of the Iowa State College, is chairman, will continue the study of the heat conductivity of various materials used in farm buildings construction. This work will also be supplemented by a study of stresses in barn framing.

The Committee on Farm Building Equipment, headed by M. A. R. Kelley, barn architect for the U. S. Department of Agriculture, will work principally along the lines of standardization, one of the first matters to receive attention being the collection of information looking to the standardization of litter carrier dimensions and sizes.

Mr. Kelley is also chairman of the committee on Farm Building Ventilation, which will continue the general study of ventilation as applied to farm buildings which has been so ably handled in the past by W. B. Clarkson, director of engineering and research for the King Ventilating Company.

Government and Industry Cooperate in Standardization

AT THE request of Herbert Hoover, Secretary of Commerce, the American Engineering Standards Committee has designated A. A. Stevenson, the retiring chairman of the Committee, as a special representative to work with the De-

partment in the cooperation between the Department's Division of Simplified Practice and the American Engineering Standards Committee.

The Division of Simplified Practice is a coordinating unit of the Department of Commerce assisting in those reductions of excessive variety and other simplifications which many industries are undertaking in order to decrease the cost of production and distribution of manufactured articles. The work of the division was organized in the latter part of 1921 and is now actively under way.

The American Engineering Standards Committee, which serves as a national clearing house for a broad field of engineering and industrial standardization, has offered Secretary Hoover the use of its machinery in carrying out the detailed work on technical projects initiated in the simplification program of the Department of Commerce. The Committee hopes to be of great value to Mr. Hoover in this simplification program of the Department. It was as a result of this hope that the designation of Mr. Stevenson as a representative came about.

The American Engineering Standards Committee has been actively at work somewhat over two years, during which time it has brought about a large measure of industry-wide cooperation. In this work more than a hundred national organizations are participating through representatives officially designated by them. The formulation of the standard for each specific project is in the hands of a working committee made up of representatives officially designated by the various bodies concerned. Eighteen standards have received formal approval as nationally recognized standards, and work on more than sixty other projects is in various stages of development. The American Engineering Standards Committee is maintained jointly by twenty-nine national organizations, including five departments of the federal government, nine national engineering societies, and fifteen national industrial associations.

There are now similar national industrial standardizing bodies in thirteen foreign countries, all but one of which were formed during or since the war. Of these the British and the German work is the most extensive, but active and important work is going forward in other countries.

Mr. Stevenson, who is a past president of the American Society for Testing Materials and who has had a most extensive experience in standardization work, is vice-president in charge of manufacture of the Standard Steel Works Company, which is a subsidiary of the Baldwin Locomotive Works.

Drain Tile Specifications approved by A. E. S. C.

AMERICAN Engineering Standards Committee has approved as Tentative American Standard the Specifications for Drain Tile (C4-21) of the American Society for Testing Materials.

The history of these specifications dates back to 1911 when the A. S. T. M. organized its Committee C-6 on drain tile to meet two very urgent conditions. The comparatively recent use, on an extensive scale, of very large drain tile in public drainage works for reclaiming wet lands had brought about the unexpected discovery that these large drain tile were quite subject to cracking in the ditch under the weight of the ditch refilling. Also the extensive production of concrete drain tile and the resulting controversy between clay tile and concrete tile producers as to the merits of the new material made it urgent that additional data be secured. The specifications were based on a series of investigations covering methods of tests, the determination of desired quality and durability of drain tile, and a study of methods of manufacture and of construction and field specifications.

Nineteen standards have now been approved by the American Engineering Standards Committee of which four have been approved as "American Standard," fourteen as "Tentative American Standard" and one as "Recommended American Practice".

Bolts, Nuts, and Rivet Standardization

RECENTLY this Society was invited by the American Engineering Standards Committee to send a delegate to the meeting of the sectional committee on standardization of bolts, nuts, and rivets proportions which met in the council room of the American Society of Mechanical Engineers on March 16. President A. J. R. Curtis appointed E. P. Stahl as the A. S. A. E. representative at that meeting.

Personal Items of Members

J. LEO AHART, Dow City, Iowa, has written a manual on tractor plowing called "The Ahart Method of Tractor Plowing." It describes a method for plowing any shape or size of field completely without the use of stakes, measuring distances, or turning on the same ground twice. It is an exceptionally valuable contribution to increase efficiency and economy in power-farming operations.

GUY H. HALL has been appointed director of the newly formed organization to be known as the National Institute of Progressive Farming, which will maintain headquarters in Chicago. Mr. Hall is well known to the tractor industry, being one of the pioneer tractor distributors. He was manager of the first five national tractor shows.

E. A. WHITE recently joined the Fordson Farming Service Bureau, Jackson Boulevard and Racine Avenue, Chicago, Illinois, as editor of "Fordson Farming," a magazine to be published by the Bureau. Mr. White was president of the Society during 1921 and is at present a member of the Council. He was formerly in charge of the department of farm mechanics at the University of Illinois, and later in charge of research work for the Holt Manufacturing Company. Just previous to accepting his present position he was technical editor of "Farm Implement News."

Wanted—Correct Addresses of These A. S. A. E. Members

NOTE: Mail is being returned from the addresses given below. These members, or others who know of their whereabouts, are requested to send the Secretary their correct addresses at once. Inasmuch as delivery cannot now be made, AGRICULTURAL ENGINEERING will not be mailed until correct addresses are received.

George J. Baker, 112 Theodore Street, Detroit, Michigan.

Claude S. Bristow, Elks Club, Portland, Oregon.

Joaquim Bertino de Moraes Carvalho, Directoria Geral da Industria Pastoril, Rua Matta Machado, Rio de Janeiro, Brazil.

George Collins, 461 Market Street, San Francisco, California.

J. D. Eggleston, 1638 Iowa Street, Dubuque, Iowa

D. M. Emery, Illinois Hotel, Bloomington, Illinois.

F. K. Flynn, 1 Main Street, Watertown, Wisconsin.

K. D. Hequembourg, 531 W. 112th St., New York City.

W. C. Kreuger, North Carolina Agricultural College, Raleigh, North Carolina.

A. M. Leoni, 3832 Reisterstown Road, Baltimore, Maryland.

J. T. Montgomery, Alva, Oklahoma.

Why let lumber rot when it is so simple to preserve it?

Teaching the Economy of Wood Preservation—

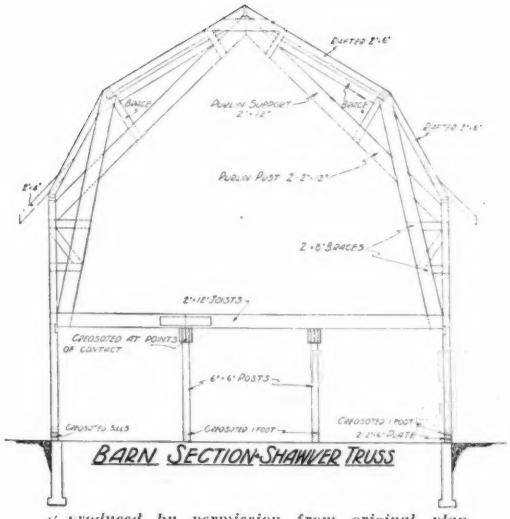
One of the ways in which agricultural colleges have increased farm efficiency is in educational work on the planning and construction of farm buildings. That this effort has borne excellent fruit must be apparent to anyone who compares farm buildings now being erected with those built a decade ago.

But the highest efficiency in farm buildings will not be attained until proper measures are employed to reduce depreciation and maintenance expense to the minimum.

This requires that every building be protected against wood decay—or at least those parts in which decay is likely to develop prematurely. Just what parts these are, are indicated on the accompanying diagram of a typical farm barn. Through the development and wide distribution of Carbosota, the benefits of wood preservation are now available to every farmer.

Carbosota is the universal wood preservative for non-pressure treatments. It is pure coal tar creosote oil, specially refined and processed to permit its effective use in Surface treatments—brushing, spraying or dipping—and in the Open Tank Process. Carbosota is obtainable from lumber dealers almost everywhere.

Many agricultural colleges and county agents have found our booklet "Long Life for Wood" helpful in teaching the economy of wood preservation. It discusses seasoning of lumber and subsequent treatment with Carbosota, and is profusely illustrated with photographs and diagrams. One or more copies will be gladly sent on request. Write to our nearest office.



Reproduced by permission from original plan (22-3-31) of Alabama Polytechnic Institute

Laminated (built-up) floor beams and wall plates to be treated with Carbosota, after framing and previous to placings:—Posts require treatment for one foot at end. Parts to be treated indicated on plan by diagonal shading.

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John Howard Rees, 2211 Commerce Building, Columbus, Ohio.

S. Y. Sweeney, 111 East Campbell Avenue, Roanoke, Virginia.

T. A. Toenjes, 1115 South Street, Waterloo, Iowa.

J. C. Weidrich, c/o Dempsey Hotel, Davenport, Iowa.

George G. Whitfield, Demopolis, Alabama.

R. S. Whiting, 908 Galt Avenue, Chicago, Illinois.

New Members of the Society

FRED J. KRITZER, chief of plan service department, James Manufacturing Company, Elmira, New York.

GEORGE EDWIN OLIVER, Onawa, Iowa.

ALLEN CLEMENT WOLFF, Weyburn, Saskatchewan, Canada.

TRANSFER OF GRADE

J. T. COPELAND, Box 64, Agricultural College, Mississippi. (From Associate to Member.)

PROF. E. W. LEHMANN, department of farm mechanics, University of Illinois, Urbana, Illinois. (From Associate to Member.)

Applicants for Membership

The following is a list of applicants for membership received since the publication of the April issue of AGRICULTURAL ENGINEERING. Members of the Society are urged to send pertinent information relative to the applicants for the consideration of the Council prior to their election.

GEORGE RAY BOYD, senior drainage engineer, bureau of public roads, U. S. Department of Agriculture, Ashland, Virginia.

FRED J. BULLOCK, Shortsville, New York.

DARISI CHENCHIAH, Kanigiri, Nelone Dt., India.

WALTER ALBERT WATTS, chief of experimental department, Massey-Harris Company, Ltd., Toronto, Ontario.

FRED READ WILEY, laboratory assistant, department of farm mechanics, University of Illinois, Champaign, Illinois.

EMPLOYMENT SERVICE

This service, conducted by the American Society of Agricultural Engineers, appears regularly in each issue of AGRICULTURAL ENGINEERING. Members of the Society in good standing will be listed in the published notices of the "Men Available" section. Non-members, as well as members, are privileged to use the "Positions Available" section. Copy for notices should be in the Secretary's hands by the 20th of the month preceding date of issue. The form of notice should be such that the initial words indicate the classification. No charge will be made for this service.

The Secretary receives several times each month from The Federated American Engineering Societies a bulletin listing the "positions open" which are reported to the F.A.E.S. Employment Service by member engineering societies. Copies of this bulletin are sent to the "men available" listed below, or other members seeking employment, as soon as received.

Men Available

AGRICULTURAL ENGINEER wants position as experimental agricultural engineer or with some agricultural publication. Graduate, 1918, agricultural college of the University of Illinois. Was editor of the Illinois agricultural students publication in his senior year. For two years employed by an explosives manufacturer as agricultural sales and service man for the State of Wisconsin. At present associated with the land clearing department of the University of Wisconsin. Age 25, married, American. MA-101

AGRICULTURAL AND CHEMICAL ENGINEER, with several years experience in research and experimental work, both in agricultural and chemical lines, desires a position on an agricultural experiment station staff or in some phases of agricultural engineering work. MA-102.

MECHANICAL AND ELECTRICAL ENGINEER, graduate of Cornell University and Armour Institute, with nineteen years of practical experience in designing, manufacturing, and marketing gasoline engines, automobiles, motor trucks and tractors, having specialized particularly on internal-combustion motors and their application, prefers mechanical work cooperating with the different manufacturing and sales departments along the lines of sales engineering, or other work into which his qualifications would fit. MA-104

AGRICULTURAL ENGINEER wants position in southwest. Graduate of University of Illinois 1915, five years practical experience on Illinois farm with power equipment, two years in charge of the agricultural engineering department New Mexico College of Agriculture; considerable garage experience and service experience on unit power and light plants. Also one summer in Philadelphia battery service station. MA-106

AGRICULTURAL ENGINEER, graduate from the agricultural engineering course of the Iowa State College, who has had a great deal of experience in sewer work and farm building construction in the southern states, is interested in securing employment with a firm specializing on farm structures or farm sanitation. MA-107

AGRICULTURAL ENGINEER, graduate in agriculture at Cornell and trained in mechanical and electrical engineering, at present assistant professor of rural engineering at an agricultural college, wants position in the same or related field. Six years teaching experience and about six years engineering experience with telephones, milking machines, field machinery, concrete pipe making machinery and gas engines. Thoroughly trained in automotive theory and practice, including repair. MA-108

AGRICULTURAL ENGINEER wants position on a farm or with some firm where an engineering and general agricultural training is required. Will graduate from the agricultural college of the Ohio State University in June 1922. Major work done in agricultural engineering and farm management. Born and raised on farm. Age 22. Unmarried. MA-109.

AGRICULTURAL ENGINEER, graduate in mechanical engineering at Michigan Agricultural College, desires position teaching all kinds of farm machinery or automotive work, or with some farm-equipment manufacturer. Will be available April 1, 1922. Has served one year as instructor in tractors and trucks, and one year conducting service schools for a leading tractor manufacturer. Can furnish best of references. MA-110

AGRICULTURAL ENGINEER, graduate of Iowa State College 1920, with several years of practical experience farming with machinery and one year's teaching experience in high school, wants employment on a large farm or in college teaching of power farming. Twenty-five years of age. Married. MA-111

AGRICULTURAL ENGINEER, with eleven years' experience in agricultural engineering instructional and extension work, is available for position. Graduate of Agricultural College of University of Nebraska. Has had farm experience. Age 38. Married. MA-112.

A National Organization Offers You Its Services

This Association will be glad to assist agricultural engineers and all people interested in improved farm buildings to learn more of the suitability and adaptability of Concrete.

Our Cement Products Bureau, for example, will be pleased to confer with you on the use of all structural concrete products such as concrete block, concrete building tile, brick, drain tile, fence posts, etc.

We have booklets and plans covering many standard farm structures. All our service is free.

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